Design and Manufacturing of Test rig to test rubber's durability

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(Caterpillar, 2006)

A thesis submitted in partial fulfillment of the requirements for the degree of

Bachelors of Engineering in Mechanical Engineering

School of Mechanical and Manufacturing Engineering,

National University of Sciences and Technology (NUST),

Islamabad, Pakistan

17 June, 2016

National University of Sciences & Technology

FINAL YEAR PROJECT REPORT

We hereby recommend that the dissertation prepared under our supervision by: <u>{Insert names of group members followed by NUST Regn No}</u> Titled: <u>{Complete FYP Topic}</u> be accepted in partial fulfillment of the requirements for the award of <u>Bachelors of Engineering in Mechanical Engineering</u> degree with (_____ grade)

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We certify that this research work titled "*Design and Manufacturing of Test rig to test rubber's durability"* is our own work. The work has not been presented elsewhere for assessment, yet. The material that has been used from other sources it has been properly acknowledged / referred.

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Dedicated to the memory of the martyrs and surviving children of APS attack in Peshawar

16 December, 2014

Acknowledgments

All praises and thanks to Allah, the Most Beneficial and the Most Merciful, for bestowing on us all the blessings in our lives. Praise be to Allah, for the blessing of being in Ummah of His last and beloved Prophet Hazrat Muhammad (SAW). Praise be to Allah for giving us strength and guidance and lending us His invisible hand throughout our lives. Alhamdulillah! The compilation and completion of this thesis would not have been possible without the all-out help and support of the very kind people around us, to only some of whom it is possible to give particular mention here. Dr. Hussain Imran, Dr. Amir Mubasher, Dr. Emad-ud-Din, Dr. Sami ur Rehman Shah, Brig. Abdul Waheed and Engineer Ayaz.

We must record our thankfulness to our fellow UG students of ME-04, for creating a collaborative, comfortable, congenial environment to work wholeheartedly. It was a wonderful experience working and studying with all of you.

The prayers, wishes, cooperation and perpetual assistance of our most beloved family members deserve a special mention. Our parents, siblings and close friends whom we consider to be our family too; comprehending this humongous task would not have been possible without your eternal support and best wishes.

Abstract

Our research is centred on a track link, which is an essential component of tanks and excavators. The track link has 2 parts, a steel part and a rubber part. The rubber part is being imported from China and it has to be tested before it can be used for large scale production.

To check the rubber's durability, companies put their excavators and tanks through a real time test and run the excavator or tank for a large distance and then check the rubber's thickness to see whether it has worn out as much as it is supposed to be, or more?

This entire process is extremely costly, tedious and time taking. It hurts a companies' financial reserves real bad.

The Rubster (our test rig) is the answer to this problem. It can accurately test a rubber's durability so that industries and companies no longer have to run their tanks and excavators for thousands of miles. What took millions of rupees to accomplish, will now take thousands only. What took months to achieve, can now be achieved in a matter of hours.

Keywords:

HIT (Heavy industries Taxila)

Tanks

Excavators

Rubber track/part

The Rubster

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Symbols

AL2024 T3	Aluminium Alloy 2024 heat treated
F	Load
t, t_1, t_2	Adherend thicknesses
t_a	Adhesive thickness
$\varepsilon, \varepsilon_{x1}, \varepsilon_{x2}$	Longitudinal strains
T	Shear stress
G	Modulus of rigidity of adhesive
E_1, E_2	Modulus of elasticity for plates
E_a	Modulus of elasticity for adhesive
l	Length of overlap
B	Width of overlap
A,B	Constants of solution of differential equation
τ_m	Mean tangential stress
τ_n,	Destructive stress
M	Bending moment
E_{Total}	Total strain energy
σ	Tensile stress
$\sigma_{p(max)}$	Max peel stress
$d\Omega$	Structural domain

Chapter 1
Introduction

1.1 Background

We live in an era of extreme industrialization. Time and money mean everything to the industry. All the big industries and companies have set up their own research divisions to further their goals of saving time and money as well as increasing efficiency without any compromise on reliability, of course. One such industry is Heavy Industries Taxila (HIT) which is the manufacturer of armored vehicles and artillery for the Pakistan Army.

They are facing a problem for the last 10 years; they cannot test a rubber’s life/durability without spending millions of rupees and of course a lot of time, too. In order to cut their costs and time, we have created the Rubster.

1.2 Aim and Objectives

The aim of our project is to cut short the costs and time taken by HIT to test their rubber’s life. The following objectives were identified in order to achieve the overall aim of this research.

- Create a new design that is optimally suitable for testing the life of a rubber.
- Manufacture such a machine which is based on our design.
- Test the machine and deliver its design to HIT.

1.3 Research Methodology:

Our research is focused on the properties of a rubber, how it wears out and what forces act on it.

Before going into designing phase, we will have to understand the type of forces that are acting on the rubber pads so that we can design a best possible accurate test rig.

1.3.1 Force Analysis:

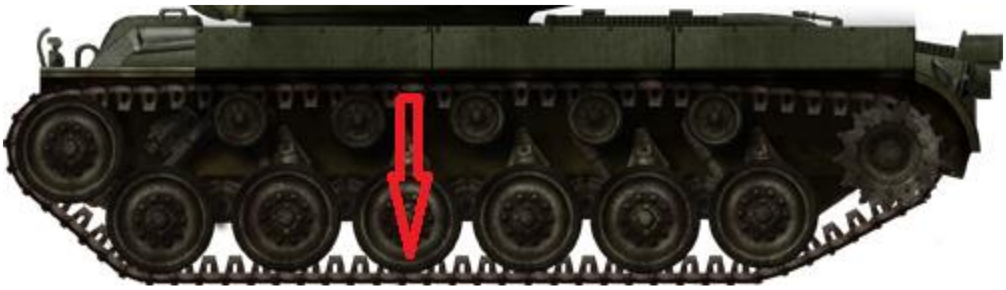

Figure 1.1

As shown in figure, all the weight of tank is acting on rubber pads through the road wheels. So rubber pads are in compressive loading/stress. Also the type of surface on the ground is not constant. So we have to create two real life conditions for basic small scale model of the test rig.

1. The Compressive Load
2. Ground Surface on which the tank travels

Further calculations will be done later on in this book as well.

As compressive load of a tank is very huge, therefore we will use an excavator for design calculations. The excavator and tank work on same principle. Same type of loading acts on the rubber pads of an excavator as on the rubber pads of a tank.

We will use Caterpillar mini excavator model 304.5 for this small scale model.

Chapter 2

Literature Review and Initial Calculations

2.1 Caterpillar 304.5

As compressive load of a tank is very huge, therefore we will use an excavator for design calculations. The excavator and tank work on same principle. Exactly the same type of loading acts on the rubber pads of an excavator as well as on the rubber pads of a tank.

We will use Caterpillar mini excavator model 304.5 for this small scale model.[1]

CAT. 304.5 Data:

Weight = 4595 Kgf

Where 1 Kgf= 9.81 N

Power = 29 KW

Maximum Speed= 4.7 Km/hr

Pairs of Road wheels on each side =5

Resistive Area of Rubber Pads = 178 cm^2

Track Pitch = 73 mm

Number of Tracks = 72

Total length of track = 73 x 72 = 5256 mm

It means in one complete revolution of track, vehicle covers horizontal distance of 5.256 m.

2.1 Compressive Stress:

Total compressive load divides into half on each side due to load symmetry and design balance condition.

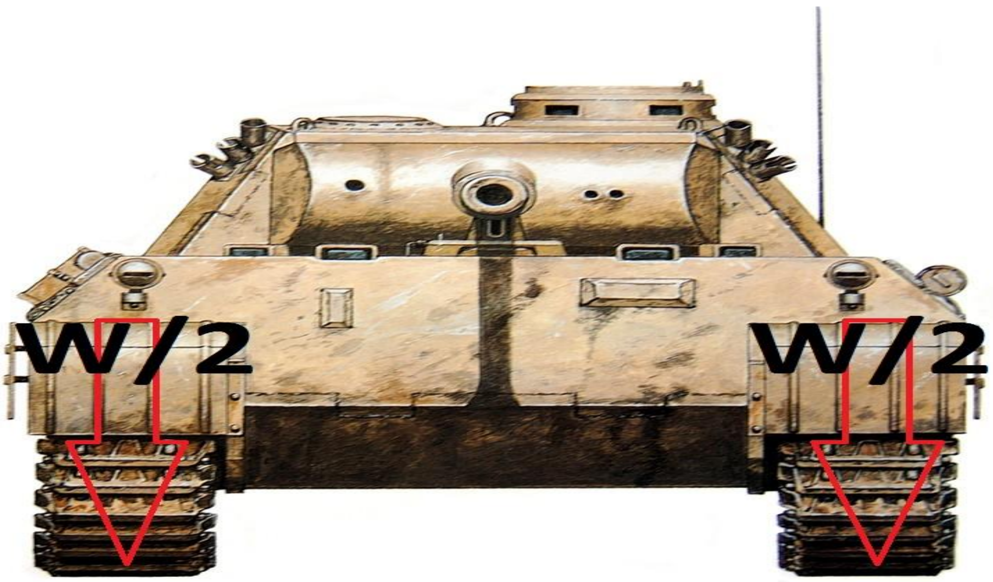

Figure 2.1

Total Load =4595 Kgf

Load on one side of vehicle = 2297.5 Kgf

As there are five pairs of road wheels on each side, therefore compressive load on one pair of road wheels will be

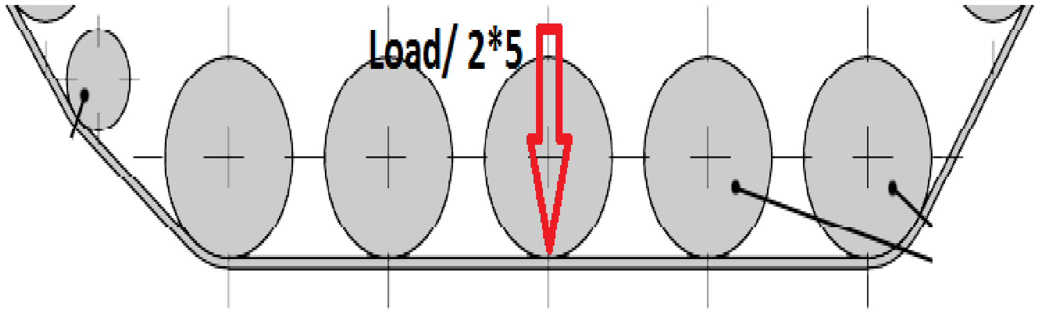

Figure 2.2

Load on single pair= 459.5 Kgf

It reduces further as it is load on one pair and in one pair we have two parallel road wheels sharing equal load. Therefore, load on single road wheel is our desired load and we will denote it with L_R. So,

$$L_R = \frac{459.5}{2} = 229.75 \text{ Kgf}$$

So, load on single road wheel is 229.75 Kgf. It is the load that will transfer from that road wheel to rubber pads under the road wheels. Therefore, each rubber pad will bear a load of 229.75 Kgf each time when it will come under loading by means of a road wheel. It is the compressive loading for which we have to design our test rig.

2.2 Stress:

Stress is loading per unit resistive area of loading. It is an internal property of any material. If we want to get best possible results that are very close to the real world scenario, we will have to produce same stress on rubber pads in even our small scale model. For this purpose, we will have to compromise on load and resistive area of load. As we are dealing with a model that is depicting a real world effect with scaled down specifications, so we will limit the forces and properties of our material to our model's requirement.

Actual stress on the rubber pads in selected excavator is,

Actual Stress= σ_A= Load /Area

We have calculated load on single rubber pad and its resistive area so;

Area= A= 178 cm^2

$$\sigma_A = \frac{229.75}{178}$$

$$\sigma_A = 1.2835 \text{ Kgf/ cm}^2$$

It is the amount of stress on a single rubber pad trough a single road wheel due to the load of vehicle. We will produce the same stress on compromised area of rubber through a compromised load.

2.3 Scaled Down Load and Resistive Area:

We have to keep stress constant that is 1.2835 Kgf/ cm^2, so we will select an appropriate value for resistive area then against this area we will calculate the load that we will use in our model.

We use value for area 50 cm^2 for our model. Therefore, applied load will be;

$A_{SD} = 50\ cm^2$

$L_{SD} = A_{SD} \times \sigma_A$

$L_{SD} = 50 \times 1.2835$

$L_{SD} = 64.175$ Kgf

So we have calculated our two required scale down parameters.

Now we have to select type of surface on which we will run this rubber pad to produce the effect and wear and tear. For our design we are using a surface with two portions:

1. It is rough surface that has been made of concrete but its contacting region has small stones coming out of the surface.
2. It is a smooth surface. It also has been made of concrete but its contacting region has a cement plaster that provides a smooth surface effect.

Finally we have selected our both required conditions i.e Compressive loading and ground surface .Now we will move towards the design phase of our model.

Chapter 3
Design Calculations

3.1 Introduction

As mentioned earlier in the thesis, a track link has two parts:[2]

(1) Steel Track (2) Rubber Pads

Figure 3.1

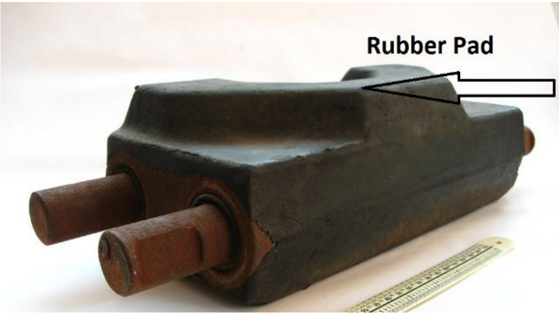

Figure 3.2

Rubber pads are in contact with ground when the vehicle is in action. Rubber pads are used for following purposes:

- To absorb the vibrations generated by collision of track link and ground
- To reduce the noise
- To keep the roads safe

When the track link is in action, rubber part wears out and its thickness reduces by an amount after each kilometer. Therefore, companies claim a certain amount of reduction in thickness of rubber pads after certain kilometers. The local consumers cannot rely on the claim of the company. Therefore, they check their claim and then make deals with them.

For example, the suppliers those provide rubber pads to HIT, claim that after each fifty kilometers, the thickness of rubber pads will reduce by 2 millimeters. Total thickness of rubber pads is 25 millimeters. Therefore, rubber pads can be used for a distance of 500 kilometers.

Heavy Industries Taxila also check the claim of rubber pads suppliers. They select random rubber pads from a lot and make a track. Then they run a tank using that track link for 500 kilometers on different surfaces e.g country side, desert, metal roads etc.

After each fifty kilometers, they check the thickness of rubber pads to check the reliability of the claim of company.

This process has the following problems:

- It takes a lot of time.
- Fuel consumption of tank is very much.
- Each tank has specific life span after which it cannot be used properly. Therefore, it is expensive.
- It takes a lot of human effort.

Therefore, we proposed an alternative method to check the rubber pads on a test rig that will give almost accurate results.

3.2 Our design and its preceding Calculations

3.2.1 Proposed Design:

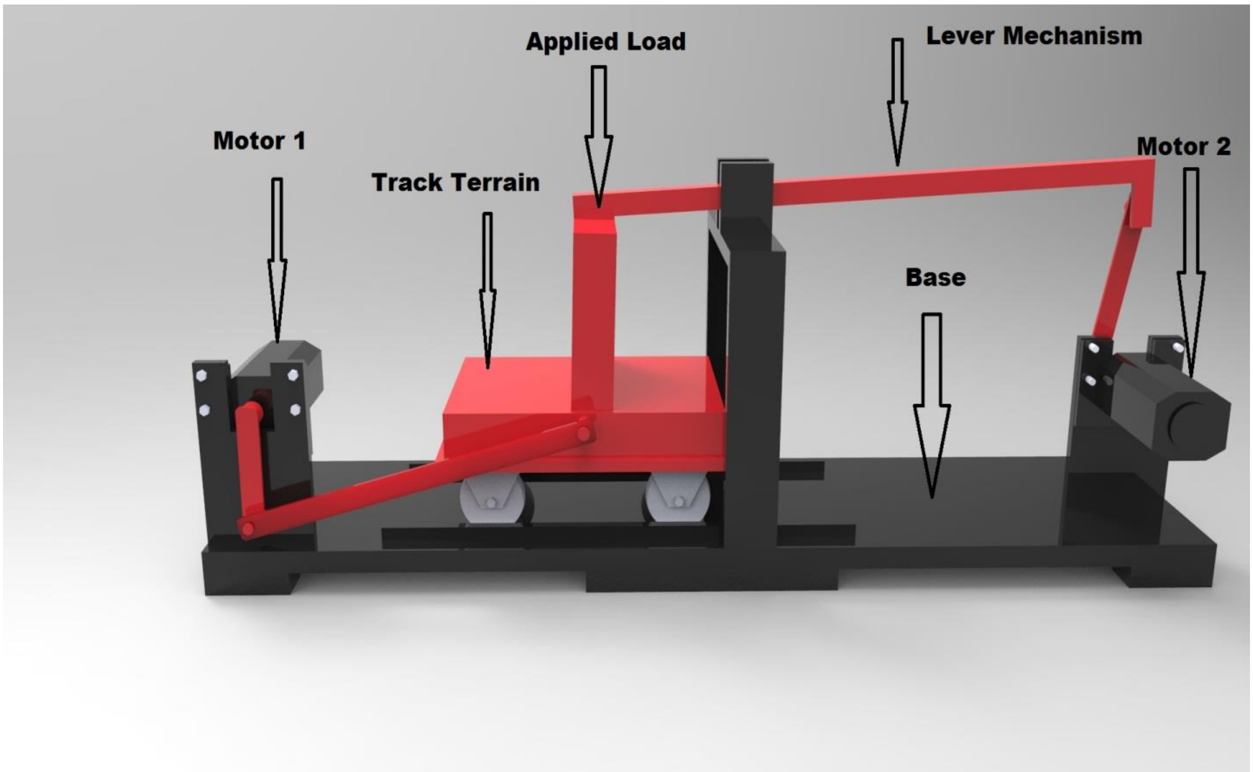

Figure 3.3

The design consists of following parts:

1. **Base:** It is made of mild steel. Its basic purpose is to provide a platform for the installation of other parts of test rig. As it is a heavy plate of mild steel therefore it also provides ground support to all the moving parts. It keeps all the design free of vibrations generated by moving parts.
2. **Motor 1:** It is a geared motor that is being used to move the track terrain back and forth. It is connected with a slider crank mechanism that converts its rotary motion into the translator motion of track terrain.

3. **Applied Load:** It is a solid block of mild steel. It is dead weight. Its weight is 64 Kg that is our desired load on the rubber pads. Its only purpose is to provide the required compressive loading.
4. **Lever Mechanism:** Lever mechanism is a very radical tool of the design. Its only purpose is to reduce the load on Motor 2 that is lifting solid weight of 64 Kg. It reduces the load on motor three times of the original load.
5. **Motor 2:** It is the same geared motor as used earlier but with different RPM. It is being used to move the dead weight up and down.
6. **Lever Station:** It is a platform on which lever system has been supported on a beam through two vertical steel bars. It is bearing all the applied load and transferring it to the base of the design.

3.2.2 Design Calculations:

Now we will show design calculations of each part and mechanism one by one.

Track Terrain:

Data:

Weight =W= 1 x 9.81

W = 147.15 N

Wheels Diameter = D= 76.2 mm

Rolling friction coefficient for Plastic-Metal surface = c= 0.2

C_l = rolling resistance coefficient with dimension length (mm)

C_l = 0.8 mm

Free Body Diagram:

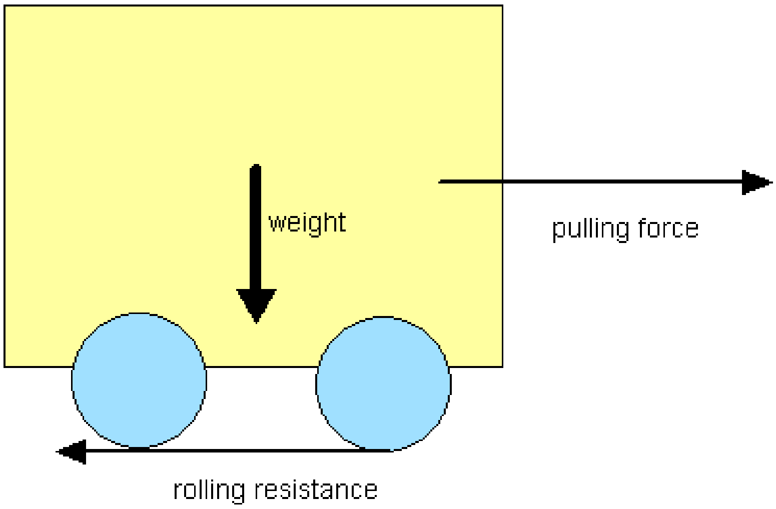

Figure 3.4

Calculation:

The rolling resistance can be expressed as

$F_r = c\ W$ (1)

Where

F_r =Rolling resistance or rolling friction (N)

c = Rolling resistance coefficient - dimensionless (Coefficient of rolling friction - CRF)

W = m g = normal force - weight - of the body (N)

The rolling resistance can alternatively be expressed as

$F_r = \frac{Cl \times W}{r}$ (2)

Where

r = radius of wheel (mm)

For Plastic-Mild Steel surface,

So,

$$F_r = \frac{0.8 \text{ x } 147.15}{38.1}$$

F_r = 3.0897 N

It is the required force to pull the track terrain.

Primary Motor:[3]

As we have calculated the required pulling force for the track terrain. Now we will calculate the produced force of our selected motor. It should provide as much force that should be equal or greater than the force required to pull the track terrain.

As we have attached a stainless steel bar to the shaft of our motor as an element of slider crank mechanism, we have to calculate its mass now.

Density of stainless steel = 7.80 g/cm^3

Volume of steel bar= 11.43 cm x 0.5 cm x 2.54 cm = 14.5161 cm^3

Mass of steel bar = 7.80 x 14.5161 = 113.22 g = 0.11322 Kg

Now we will calculate the torque acting on the steel bar.

T_1 = Force x Moment Arm

T_1 = 3.0897x 0.1143 = 0.3531 N.m

We have geared motor with following specifications;

Basic RPM = 1400

Output RMP= 25

Power = 300 W

I

Its provided torque will be,

$$T = \frac{300 * 60}{25 * 2 * pi}$$

T= 114.6 N.m

It is greater than our required torque so we can use this motor easily.

Lever Mechanism:

The applied load on the rubber pad is very large that is 64 Kgf. We will have to use a heavy motor to move it up and down that we cannot afford in this design. And it will also make the design unpleasant and will produce more vibrations. Therefore, to reduce the load on motor, we are using a lever mechanism that will reduce the weight three times for the motor.

As we know the lever mechanism works on the principle of balancing torque on both ends of lever.

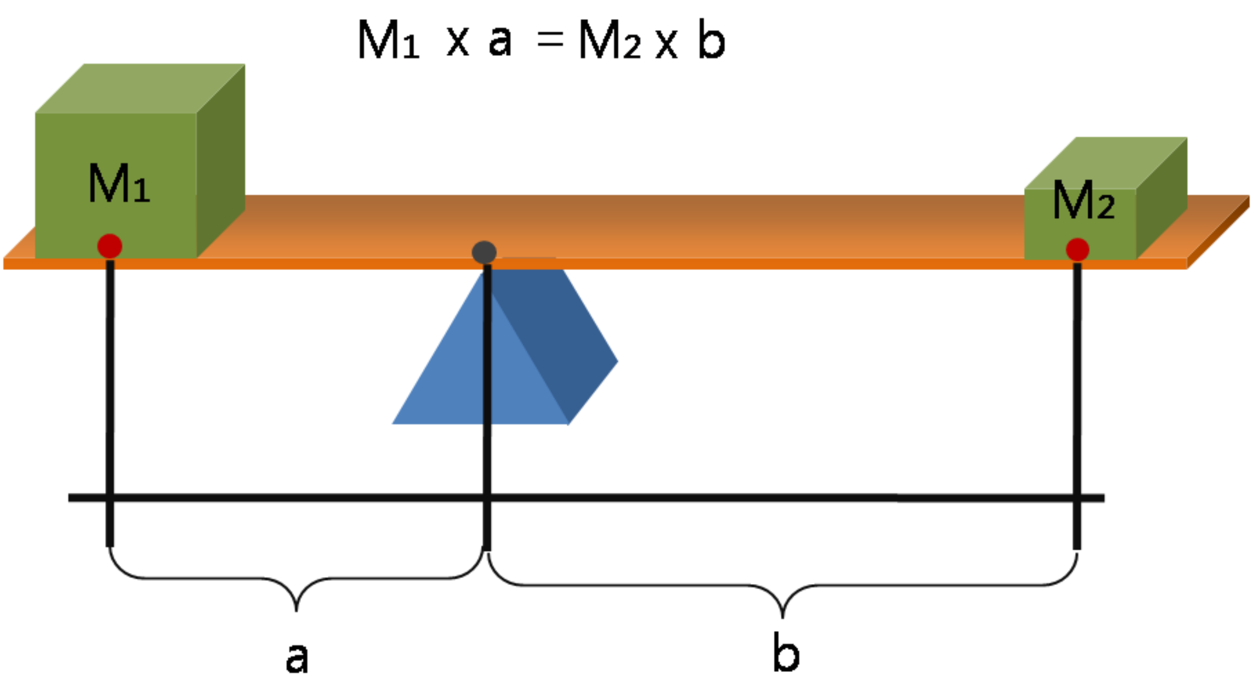

Figure 3.5

We can change the effect of load on any end by changing its distance from pivot point or fulcrum. In mathematical form it is written as:

M_1 x a = M_2 x b

Where,

M_1= Applied load = 64 Kgf

a= Distance of applied load from fulcrum

M_2= Load on motor

b= Distance of motor load from fulcrum

We can also write previous expression as given below;

$$\frac{\mathrm{M1}}{M2} = \frac{\mathrm{b}}{a}$$

It means that the ratio of loads is equal to the inverse of ratio of their distance from fulcrum. If we want to reduce load on motor by three times, we will have to make their ratio equal to 3.

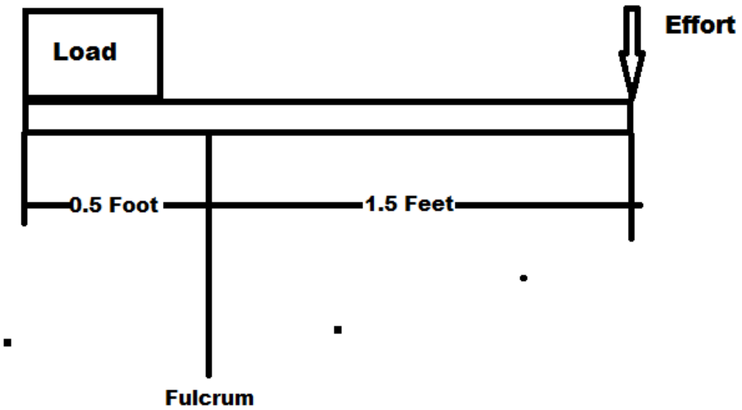

Figure 3.6

So we use following dimensions;

a= 0.5”

b=1.5”

- $\Rightarrow$ $\frac{b}{a} = \frac{1.5}{0.5} = 3$
- $\Rightarrow$ $M_1 = M_2 \times 3$
- $\Rightarrow$ $M_2 = \frac{M1}{3}$
- $\Rightarrow$ $M_2 = \frac{64.175}{3}$
- $\Rightarrow$ $M_2 = 21.39$ Kgf

It is the load that will appear on the motor to move applied load up and down.

Secondary Motor:

We have calculated the applied load on the motor. Now we will calculate the applied torque on rotating disc that is attached to motor as a part of slider crank mechanism.

T_1 = Force x Moment Arm

$T_1 = 21.39 \times 9.81 \times 0.0381 = 7.9947$ N.m

We have geared motor with following specifications;

Basic RPM = 1400

Output RMP= 75

Power = 300 W

Its provided torque will be,

$$T= \frac{300 * 60}{75 * 2 * pi}$$

T= 38.197 N.m

It is greater than our required torque so we can use this motor easily.

Lever Station:

It is also a mild steel plate on which applied load is acting directly with following specifications;

L = 0.3048 m

W= 0.0635 m

H= 0.01905 m

Free Body Diagram:

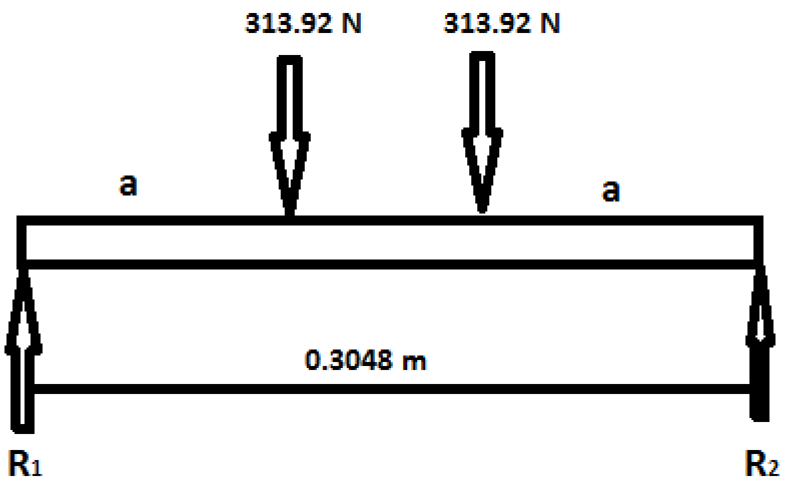

Figure 3.7

Where a= 0.1397 m

Moment of Inertia:

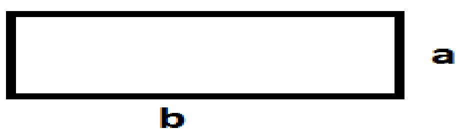

Figure 3.8

$a = 0.01905$ m

$b = 0.0635$ m

$$I = \frac{b*a3}{12}$$

$$I = \frac{0.0635*6.913*10-6}{12}$$

$I = 3.658284 \times 10^{-8}$

Maximum Bending Moment:

First we will calculate the reaction forces acting on the plate.

$\sum M_1 = 0$

- ⇨ $313.92 * 0.1397 + 313.92 * 0.1651 = R_2 * 0.3048$
- ⇨ $R_2 = \frac{95.6828}{0.3048}$
- ⇨ $R_2 = 313.92$ N

$\sum F_Y = 0$

- ⇨ $R_1 + R_2 = 627.84$
- ⇨ $R_1 = 627.84-313.92$
- ⇨ $R_1 = 313.92$ N

The maximum bending moment on plate will be ;

$(M_b)_{Max} = R_1*0.1397$

$(M_b)_{Max} = 43.85$ N.m

Shear Force:

In this case, shear force is equal to the reaction force. As we know both reaction forces are also equal

- ⇨ $R=V=313.92$ N

Deflection:

The resultant maximum deflection will occur at center;

$$\Delta = \frac{P*a}{24*E*I}\ (3\ l^2 - 4\ a^2)$$

Where

E = 210 GPa

l= 0.3048 m

Now,

$$\Delta = \frac{313.92*0.1397}{24*210*10+9*3.658284*10-8}\ (3*\ 0.3048^2\text{-}4*0.1397^2)$$

$$\Delta = 4.77238\ \text{x}10^{-2}\ \text{mm}$$

Bending Stress:

Acting bending stress on the beam will be;

$$\sigma_b = \frac{M*c}{I}$$

Where,

C= Vertical distance from neutral axis

$$\sigma_b = \frac{43.85*0.009525}{3.658284*10-8}$$

$$\sigma_b = 11.417\ \text{MPa}$$

It is acting bending stress on the plate due to applied load.

Bending Moment and Shear Force Diagram:

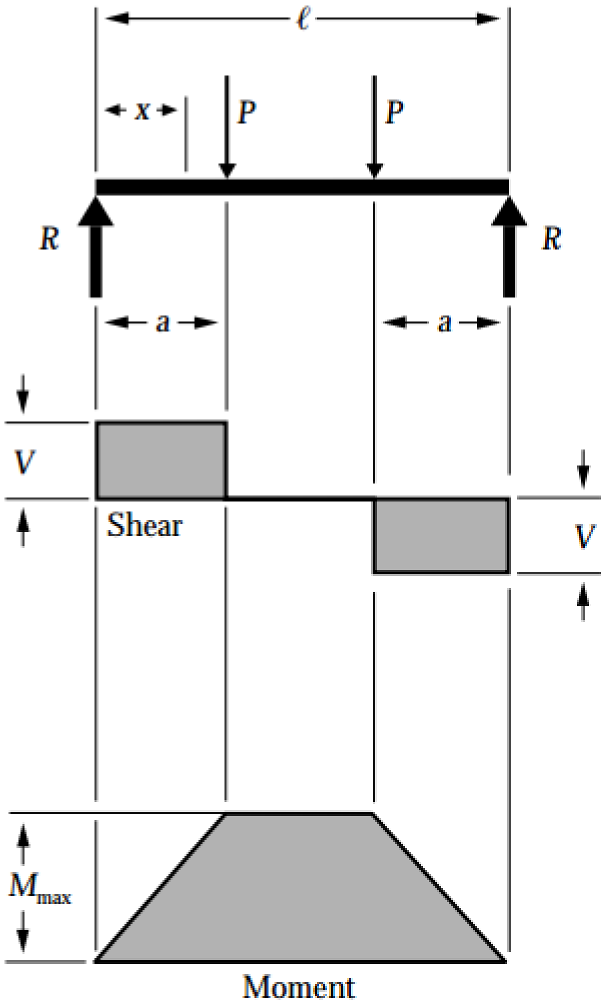

Figure 3.9

Base:

Base is made up of mild steel. It is a rectangular plate with following specifications.

L= 4 feet

W= 1 foot

Width = 2 inches

Free Body Diagram:

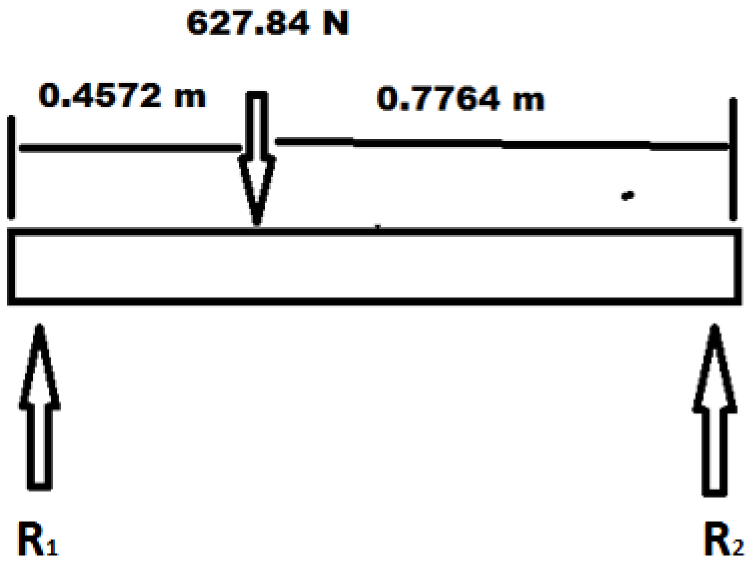

Figure 3.10

Moment of Inertia:

The moment of inertia of the beam is;

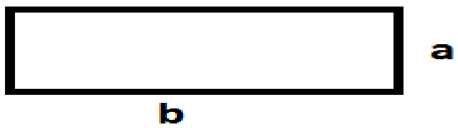

Figure 3.11

a=0.0508 m

b=0.3048 m

$$I = \frac{b*a3}{12}$$

$$I= \frac{0.3048*0.00013109}{12}$$

$I = 3.32985 \times 10^{-6}$

Maximum Bending Moment:

First we will calculate the reaction forces acting on the plate.

$\sum M_1 = 0$

- ⇨ $627.84 * 0.4572 = R_2 * 1.2336$
- ⇨ $R_2 = \frac{627.84*0.4572}{1.2336}$
- ⇨ $R_2 = 232.69$ N

$\sum F_Y = 0$

- ⇨ $R_1 + R_2 = 627.84$
- ⇨ $R_1 = 627.84-232.69$
- ⇨ $R_1 = 395.15$ N

The maximum bending moment on plate will be ;

$(M_b)_{Max} = R_1*0.4572$

$(M_b)_{Max} = 180.66$ N.m

Shear Force:

The acting shear forces V_1 and V_2 on the plate are equal to the reaction forces acting on the beam.

- ⇨ $V_1 = R_1$
- ⇨ $V_2 = R_2$

Deflection:

The resultant deflection at the point of load will be;

$\Delta = \frac{P*a*a*b*b}{3*E*I*l}$

Where

E = 210 GPa

l= 1.2192 m

Now,

$$\Delta = \frac{627.84*0.00258*0.0929}{3*210*10+9*3.32985*10-6*1.2192}$$

Δ = 5.8836 x10^{-5} mm

Bending Stress:

Acting bending stress on the beam will be;

$$\sigma_b = \frac{M*c}{I}$$

Where,

C= Vertical distance from neutral axis

$$\sigma_b = \frac{180.66*0.0254}{3.32985*10-6}$$

σ_b = 1.378 MPa

It is acting bending stress on the plate due to applied load.

Bending Moment and Shear Force Diagram:

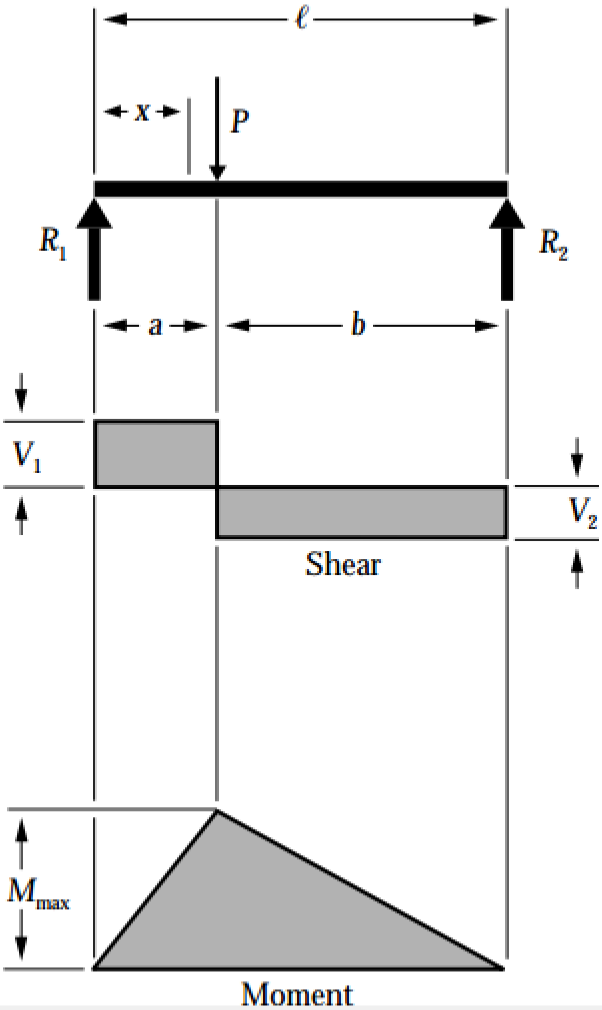

Figure 3.12

3.3 Actual Working Mechanism

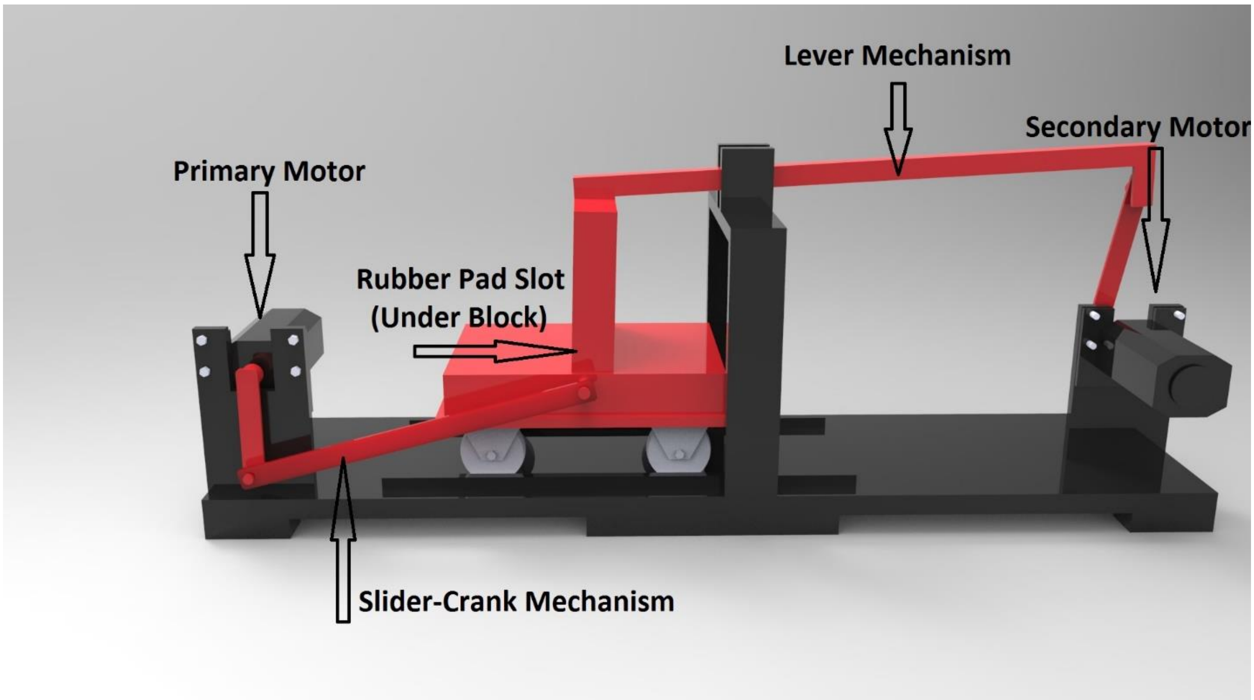

Figure 3.13

As shown in above picture, there are two sources of motion:

1. **Primary Motor:** It is driving slider crank mechanism to provide translation to track terrain so that two different surfaces can be provided to rubber pad.
2. **Secondary Motor:** It is driving another slider crank mechanism that is further driving a lever mechanism.

There are two mechanisms being used:

1. **Slider-Crank Mechanism:** To convert rotation into translation.
2. **Lever Mechanism:** To reduce the load on secondary motor.

Working:

When the system is started, primary motor made the track terrain to move back and forth on the base plate. On the other hand, secondary motor provides up and down motion to the solid block that applies compressive load on rubber pad. Hence, producing compressive stress on the rubber pad that is almost as same as in actual case on the rubber pads.

When primary motor completes its one revolution, secondary motor completes its five revolutions. It means in one loading cycle, compressive load is applied on the rubber pads five times. In actual design, in one complete cycle of track, each rubber pad comes five times under compressive loading. Hence, loading cycle of our test rig is equal to the loading cycle of excavator 304.5. Rest of the time, pads remain free of loading therefore we have not included that time in our design.

Chapter 4
Results and Discussion

4.1 Testing Procedure

In the actual case, each rubber pad comes under loading five times in a complete cycle of track. The same has been depicted in our design. In one revolution of secondary motor, secondary motor completes its five revolutions.

To test rubber pads of any hardness value, insert the rubber pads in the slot under the solid block. Then run the test rig and calculate the time for which it has been run. Using following relations, you can measure the reduced thickness after certain kilometers.

Relation between Thickness and Covered Kilometers:

As we know in one complete cycle of track, CAT 304.5 covers a fixed amount of distance.

In one complete cycle;

D=5.256 m=0.005256 Km

The loading cycle of our design is equal to the loading cycle of excavator, therefore,

One rotation of primary motor= One complete cycle of track

Therefore, in one rotation of primary motor rubber pads will cover same distance that is

D=0.005256 Km

⇨ 1 rotation = 0.005256 Km

Hence, by measuring the run time of test rig we can calculate the number of cycles;

Motor RPM = 25

We can simply calculate the total number of cycles that will be covered in that time, through that cycles we will calculate the number of kilometers that pad will cover. Finally, we will measure the reduced thickness of rubber pads after that distance.

4.2 Results

We have tested these three types of rubber pads on test rig.

Soft Rubber Pad:[4]

Tensile Strength= 46 Kg/cm2

Hardness= 45-47 shore type A

Tear strength= 18.2 Kg/cm2

Medium Hardness Rubber Pad[4]

Tensile Strength= 52 Kg/cm2

Hardness= 50-52 shore type A

Tear strength= 22.4 Kg/cm2

Hardest Rubber Pad:[4]

Tensile Strength= 62 Kg/cm2

Hardness= 70-72 shore type A

Tear strength= 38.2 Kg/cm2

Results:

1- Rubber pads number 1 with low hardness value give following results.

Time= 5 minutes;

Total Number of cycles = 5*25 = 125

As

1 cycle = 0.005256 Km

125 cycles = 0.657 Km

Reduced Thickness= 2 mm

If we use rubber pads of soft rubber with specifications as listed above, its thickness will reduce by 2 mm after 0.657 Km.

2- Rubber pads number 2 with medium hardness value give following results.

Time= 5 minutes;

Total Number of cycles = 5*25 = 125

As

1 cycle = 0.005256 Km

125 cycles = 0.657 Km

Reduced Thickness= 1.7 mm

If we use rubber pads of soft rubber with specifications as listed above, its thickness will reduce by 1.7 mm after 0.657 Km.

Chapter 5
Conclusions and Future Work

5.1 Conclusions

In this project which involved both research as well as manufacturing with testing as well, we have come to conclude that with our design it is possible to obtain a rubber's durability on this simple test rig, accurately. We have carried out the proper testing procedures and concluded that there is no need to run an excavator or a tank for thousands of kilometers.

Using our design, industries can save precious money, time as well as a lot of effort.

5.2 Future Work

1) Our design has been collected by HIT, who is set to work on it on a large scale.
2) We will help HIT with the process along the way. Whenever they need our assistance.

References

[1](www.cat.com/en_US/products/rental/equipment/excavators/mini-excavators/752014, 2016)

[2] (www.engineeringtoolbox.com/rolling friction, 2016)

[3] (www.alibaba.com/showroom/gear motor, 2016)

[4] (www.boards.straightdope.com/sdmb/showthread.php, 2016)

[5] (www.services.1kiwa.com/polymers/rubber-investigation-prediction-service-life, 2016)

[6] (R.C.Hibbeler, 2013)

[7] (G.Budynas, 2003)